High Resolution Gamma-Ray Spectroscopy at the Institut Laue-Langevin

Paolo Mutti, Hans Börner, Michael Jentschel

Institut Laue Langevin - 6, rue Jules Horowitz BP 156 - 38042 Grenoble Cedex 9 - France

The 58 MW reactor of the Institut Laue-Langevin in Grenoble (France) is currently the most intense thermal neutron source in the world. The reactor forms the basis for a research program covering a wide variety of fields, supplying neutrons to a broad range of instruments. In the case of the two gamma-ray spectrometers operating at ILL, the gamma-rays emitted after neutron capture can be recorded with parts-per-million resolution. This is achieved by diffracting the gamma-rays with almost perfect Si or Ge crystals. Precise measurement of the respective Bragg angles and the crystal lattice spacing permits the determination of wavelengths or energies. The high resolving power of $\Delta E/E \sim 10^{-6}$ allows accurate determination of the energies of the emitted gamma-rays following the neutron capture, and therefore precise neutron binding energy measurements. This, in combination with precise atomic mass data, leads access to the Avogadro constant. Moreover, this extraordinary energy resolution allows measurements of tiny Doppler effects caused by the de-excitation processes of nuclei following neutron capture. Thereby atomic recoils can be induced by the subsequent emission of gamma-rays or in various beta decay scenarios by the emission of electrons and/or neutrinos. From the analysis of those Doppler broadened line profiles it is then possible to gather information on the lifetime of the nuclear state which is depopulated by the measured transition and on the slowing down process of the recoiling atoms, which is determined by the inter-atomic potential. Measured lifetimes provide a sensitive test of the validity of different theoretical description of the behavior of a nuclear system. An overview of the present experimental activity undergoing at the two ILL gamma-ray spectrometers will be given with emphasis on few selected examples.

Email: mutti@ill.fr